

## REVIEW ARTICLE



# Etiology, complications, key systemic and environmental risk factors in dental implant failure

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## Abstract

The chance of implant failure is the matter of great concern to implantologists. Hence, the extending knowledge on this inevitable phenomenon is clinically essential. Peri-implantitis is one of the implant failure factors. The lesion is an inflammatory reaction recognized by the loss of implant-supporting bone and diagnosed based on clinical inflammatory symptoms (such as hyperplastic soft tissue, pus discharge, color change of peri-implant marginal tissues, and gradual bone loss). Adult chronic periodontitis is a type of differential diagnosis in that it has considerable commonalities. Implant failure may also be due to surgical trauma, micro motion, and overloading. Implant failure is due to the lack of osteointegration, which is generally identified by implant loose and radiologic radiolucency. The other phenomenon is "fracturing implant" identified by a progressive loss of marginal bone but with no remarkable looseness. In this paper, we will shortly investigate causes, and effects of implant failure, and applicable parameters of the process. The aim of this review is to summarize the etiology, and complications of the dental implant failure, and its related risk factors including systemic disease, periodontal disease, and environmental factors.

**Keywords:** Dental implant failure, marginal bone loss, peri-implantitis, risk factors, smoking

## Introduction

Building on modern researches and information of biological principles, the science of implantology is increasingly extending the connection between living tissues and artificial structures. Despite its favorable outcome, some cases of implant treatment failure are reported.<sup>[1]</sup>

According to some quantitative criteria, implant failure is defined as "implant efficiency decrease lower than acceptable level." The definition embraces different clinical status: All tangible loose cases to the loss of implant's adjacent bone to more than 0.2 mm after the first loading year<sup>[2]</sup> or bleeding depth more than 5 mm from probing depth.<sup>[3]</sup> The difference between "implant failure" and "fracturing implant" is important, clinically. "Implant failure" is due to lack of osseointegration, which is generally recognized by implant looseness and peri-fixture radiolucency.<sup>[4]</sup> Failure procedure may be sometimes slow but continuous.<sup>[5]</sup> The condition is recognizable by progressive loss of marginal bone but with no remarkable looseness, so it is called "fracturing implant."<sup>[4]</sup>

## Implant Complications and Failure

Implant complications and failure are thoroughly discussed in a review article.<sup>[6]</sup> Three major etiologic factors (infection, improvement disorder, and overloading) were named as factors of implant failure and complication:

Infection: Bacterial infection which caused the implant failure can be occurred in any time period.<sup>[7]</sup> At present, some terms are used for indicating implant failure or its complication as follows:

- Peri-impant disease
- Peri-implant mucositis
- Peri-implantitis.

The peri-implant disease is a general term used for elaborating inflammatory reactions in the soft tissue around the implant.<sup>[8]</sup> Peri-implant mucositis is used for describing reversible inflammatory responses in soft tissues around the implant. It seems that other complications of the soft tissues (mucositis, hyperplastic, fistula, and mucosal abscess) mainly have infectious causes.<sup>[9]</sup> Fistula and hyperplastic mucositis are often presented with the looseness of prosthesis components.<sup>[10]</sup>

An abscess can sometimes be developed by trapped food particles in the gap around the implant.<sup>[11]</sup> Peri-implantitis is defined as inflammatory response along with bone loose in the soft tissue around the implant.<sup>[4]</sup> Plaque-induced infection on exposed surface of biomaterials can be categorized as kind of peri-implantitis.<sup>[12]</sup> According to a study,<sup>[12]</sup> peri-implantitis was considered as a site-specific infection, which has many common characteristics with adult chronic periodontitis.

**Improvement disorder:** It seems that the intensity of surgical trauma (lack of irrigation and excessive temperature), micro-motion and some other topical, and systematic features of the host playing a significant role in the implant failure.<sup>[11]</sup>

**Overloading:** Implant failure overloading is a condition, in which the dropped load on the implant is more than bone strength capacity. Failures, which occur between abutment connection and prosthesis delivery (are probably due to inappropriate loading condition or prosthesis procedures) are pertinent to overloading.<sup>[5]</sup> Implant failure is also due to improper surgical techniques, weak bone structure, inappropriate prosthesis design, and traumatic loading conditions.<sup>[13]</sup>

### Evaluative Parameters of Implant Failure

Since implants are different in terms of design, surgical technique, and loading condition, they should be investigated by various methods. The most prevalent diagnosis criteria for evaluation of implant failure are the followings:

#### Clinical infection symptoms

Infection is the most common complication arises within the course of improvement. It includes swell, fistula, pus discharge, early or late mucosal wound dehiscence. Early mucosal wound dehiscence not only causes infection but also can bring about the inappropriate design of flap or early establishment of the denture.<sup>[14]</sup>

Early or late occurrence of complication may result in major consequences because in early complication implant stabilizer agent or the so called bone healing process is interrupted. Late symptoms of progressive marginal infection can cause implant failure.<sup>[15]</sup>

Clinical symptoms of infection such as hyperplastic soft tissue, pus discharge, the color change of marginal peri-implant tissues, etc., are symptoms, which need an interruption. Infection symptoms (early or late) are not enough for defining implant precaution individually and should be investigated in line with other parameters such as radiographic alteration or looseness. In cases of absent of other parameters, however, the lack of treatment of clinical infection symptoms may bring about implant failure. In general, infection symptoms are rather an indicator of a complication than implant failure.

#### Tangible clinical looseness

Implant looseness is the main sign of treatment failure. Sometimes the clinical condition exists but there is no sign of bone alteration in radiography.<sup>[16]</sup>

Different kinds of recognized looseness are horizontal, vertical, and rotational.<sup>[17]</sup> The reverse torque test is suggested for recognition of loose implants<sup>[18]</sup> and further evaluation of horizontal mobility of periotest machine.<sup>[19]</sup>

Rotational mobility could be a sign of interruption in the level of connection between the bone and the implant, but horizontal and vertical mobility may be related to bone loss and the presence of soft tissue capsule.<sup>[9]</sup>

#### Radiographic failure sign

Radiography still remains as one of the main methods of implant failure identification. The quality of radiographs and the experience of the clinician are two critical factors for evaluating the condition of the implant in radiography.<sup>[16]</sup> Providing standard periapical radiographs is essential for identification of peri-implant radiolucencies or diagnosis of progressive loss of the marginal bone.<sup>[20]</sup> The face of peri-implant radiolucency indicates a lack of direct implant-bone connection and the probable loss of implant stability, while, in cases of increased marginal bone loss, the implant could be stable.

### Microbiology of Peri-implantitis and Peri-mucositis and Comparison with Periodontitis

Oral biofilm is the first etiological factor in peri-implant mucositis known as the first encounter of the host defense, biofilm reflect a fight affecting the natural tooth condition. Initial adhesion of the bacteria to the implant could be variable concerning the type surface topography. Implants with uneven surfaces increase the risk of formation of bacterial colonies.<sup>[21,22]</sup> In general, positions with periodontitis and peri-implant inflammation include more gram-negative bacteria than healthy positions.<sup>[23]</sup> Types of bacteria, which are seen with healthy and failed implants are like those bacteria existing in healthy and corrupted teeth, however, there are some significant discrepancies.

Reported risk factors for surrounding mucositis and peri-implant inflammation include the patient's periodontitis record.<sup>[24]</sup> Possibly, in case that surrounding dental pathogens, which are existing in peri-implant pockets be the same as natural teeth pathogens, then the host response and deconstruction of adjacent soft and hard tissues would be the natural teeth.

#### Smoking

Peri-implant and implant failure risks and inflammation factors are numerous. These factors include systematic disease, genetic traits, habitual use of drugs or alcohol, smoking, periodontal disease, radiation therapy, diabetes, osteoporosis, dental plaque, lack of oral health.<sup>[25-27]</sup> Smoking and its relationship with periodontitis have been the subject of much interest among the related studies.<sup>[28,29]</sup> The fact that smoker patients have more periodontal injuries than non-smokers is well-documented. According to the results of a project conducted by Karbach *et al.*,<sup>[30]</sup> smoking is the most important factor information of dental inflammatory mucositis. By the increase of dental implant

cases and patients application for the spread of the implant, most dentists are wondering whether the placement of the implant in smokers could lead to a failed dental reconstruction or not.

Appropriate placement of the implant is crucial, especially when the alveolar ridge is thin. D'haese and De Bruyn<sup>[31]</sup> found a little bias between the place of implantation and the real placement of implant in smokers while the bias did not observe in non-smokers. These researchers surmised that since the mucosal tissues are thicker in smokers the stability of appropriate surgical guide or prosthesis investigation will decrease, and this could lead to a change in final placement of the implant.

The various research results have shown that making the decision to the place of implants in smokers might not be possible easily.<sup>[32-37]</sup> The best method for smokers is to follow a smoke cessation program, in a way that they quit smoking prior to the implant. Smoking has a negative effect on the implant in patients with machined surface implants, fixed prosthesis, no marginal bone, bone-implant interface, and interleukin-1 (IL-1) genotype. There is no consensus among dentists for dental implants in smokers. Smoke cessation program seems to be an ideal solution, but results are not that much satisfying. Dentists who perform implants for smokers should clearly explain the high probability of the implant failure in every individual.

## Systematic Risk Factors

### Diabetes

The relationship between diabetes and periodontitis has been studied abundantly.<sup>[38,39]</sup> Some of these studies illustrate a reciprocal connection that the general improvement of a disease may ameliorate other studies, as well. Hyperglycemia or high blood sugar condition in diabetes, unless assessed accurately could cause changes in the glycosylation of advanced products/receivers at the end of the advanced glycation end products (AGE)/receptor for AGE and ligand receptor activator of nuclear factor- $\kappa$ B, and the osteoprotegerin and can lead to overall safety imbalance and cytokines, as well as cell stresses. By increase in tissue destruction, this imbalance could cause periodontal pathogenesis and impaired healing. It seems that there is dependent dosage relationship between periodontitis and diabetes intensity and evidences indicate that periodontitis control could improve diabetes.<sup>[38,40]</sup> Similarly, patients with controlled diabetes are more exposed to periodontitis diseases.<sup>[41,42]</sup>

### Obesity/hyperlipidemia

Some studies suggest a positive correlation between obesity or hyperlipidemia and periodontitis,<sup>[43-45]</sup> especially because the overweight is considered a metabolic syndrome. Usually, there is a little information on how hyperlipidemia affects the implant failure or the peri-implant inflammations.

## Impaired organ function

There are limited numbers of researches on the relationship between the implant failure and impaired organ function. Studies that concentrating on the implant success in patients with transplanted organ (such as heart and liver) found that the clinical parameters and performed radiographies of dental implants in these individuals shown no significant difference with that of healthy people.<sup>[46-48]</sup> Since these studies include patients with resultant immune deficiency of transplanted organ, more researches are required for determining the effect organ transplant failure on dental implant failure and/or implant inflammation.

## Osteoporosis

Osteoporosis is the result of bone density loss and is regarded as a preventive factor for a dental implant. Considerable numbers of new studies were concentrated on treatment of osteoporosis with bisphosphonates. Latest articles indicated that there is no limitation for the implant in patients with osteoporosis.<sup>[49,50]</sup> According to a study, on 3224 performed implants for 746 women aged 50 or above, the bone mineral density on subgroup of 129 women with 646 implants with osteoporosis and with no osteoporosis indicated that in no cases the osteoporosis is considered as a potential risk for the implant failure.<sup>[51]</sup> In this paper, the risk of implant failure in smokers was 2.6 times more than that of non-smokers.

## Hormonal disorder

Fu *et al.*<sup>[52]</sup> illustrated the effect of glucocorticosteroids, non-steroidal anti-inflammatory drugs, and statins- on the implant treatment. In general, non-steroidal anti-inflammatory drugs have a harmful impact on bone connection to the implant and post implantation bone density while it seems that strains have a positive effect on bone formation. Several studies on animals investigated the topical application of growth hormones have shown a positive effect in bone formation, and bone density loss in low-level estrogen.<sup>[53-56]</sup> Moy *et al.*,<sup>[57]</sup> indicated that women aged 60-79 are more potential to the risk of implant failure than women aged 40 or younger. However, according to this study, post-menopausal women who receiving estrogen are 2.55 times more at the risk of implant failure than women in the same age with no hormonal treatment.

## Medications

In addition to bisphosphonates, there seems that no other drug is directly related to the implant failure. According to another study investigating the implants in patients with hypothyroidism, a year after the first stage of implant placement bone loss and undesirable response of the soft tissue was evident, while increase in the risk of implant failure was not observed.<sup>[58]</sup> By studying animals and as can be seen by reducing radiography, administration of cyclosporine to rabbits was in relation with the

bone loss rate.<sup>[59]</sup> Further studies are required for determining the direct effects of drugs on the implant failure and peri-implant tissues.

### Bisphosphonates

Usually, most patients consume bisphosphonates for treating osteoporosis or during cancer treatments. Osteonecrosis of the jaw is considered as a problem that might be seen in some patients consuming bisphosphonates.<sup>[60]</sup> Bisphosphonate-related osteonecrosis of the jaw (BRONJ), which is also named bisphosphonate-induced osteonecrosis of the jaw could occur in patients using oral or intravenous bisphosphonates.<sup>[60]</sup> Dentoalveolar trauma, like dental extraction, could lead to BRONJ, seemingly.<sup>[60,61]</sup> Dental implant placement in patients under bisphosphonate treatment calls for accurate investigation. The effect of bisphosphonates on osteointegration of the dental implant is not clear. Shabestari's *et al.* group placed 46 ITI implants in 21 women with osteoporosis using bisphosphonates.<sup>[62]</sup> No implant movement has been reported, and no implant inflammation was seen through the experiments. No effect was observed concerning implant location, type of prosthesis, front teeth, or time of implant beginning on the success of osteointegration. Zahid *et al.*<sup>[63]</sup> conducted a study on 227 patients and reported surgical complications, the number of subjects with implants, implant failure, age, sex, smoking, body condition, and drugs. Among 51 performed implants in 26 patients who are using bisphosphonates, three implant failures were seen, and the success rate was 94%. No other variable was related with failure or the proposed topics other than bisphosphonates.

### Radiotherapy

Radiotherapy treatments are mostly administered for head and neck cancers. Harmful effects include dry mouth and dysfunction of the radiation zone. The new systematic review is conducted on irradiation and dental implant by Chambrone *et al.*<sup>[64]</sup> investigating the number and percentage of the loss implants except those only placed in transplanted area. The risk of implant failure for implants placed in radiated bones is 174% more than non-radiated bones. The risk of implant failure in the upper jaw is 496% more than lower jaw implants. To the best of author knowledge, there is no sign to approve that hyperbaric oxygen therapy influenced the implant failure.

### Genetics

Genetic polymorphisms have been studied for evaluating their potential role in the implant failure or implant inflammation. Those genes, which have been investigated for periodontitis and concentration on inflammation and bone cycles, were studied in parallel. A new study evaluated IL-1, TNF- $\alpha$  genotypes, and titanium implant placement; and reported that the implant failure is related significantly to increasing the number of risk genotypes of IL-1  $\beta$  and TNF- $\alpha$ .<sup>[65]</sup>

### Combination of the Risk Factors

Although some systematic diseases like cardiovascular diseases are not individually considered a risk for the implant failure, a combination of the risk factors could cause dental implant failure.<sup>[66]</sup> Extensive researches conducted by Moy *et al.*,<sup>[57]</sup> on 4680 implants in 1140 patients with the same surgery within 20 years and the potential risk of implant failure has been studied. The study carried out linear regression analyses on a number of variables and concluded that diabetes, smoking, and head and neck radiography are significant predictions in the implant failure. More interestingly, they indicated in an analysis that implant failure in healthy people is more than those who are exposed to the risk. Authors concluded that these three variables were no definitive contraindication for implant placement. A recent meta-analysis of 51 studies includes more than 40000 implants, which evaluating the relationship between the implant failure and smoking, radiotherapy, diabetes, and osteoporosis.<sup>[26]</sup> The mentioned study illustrated the positive relationship between smoking and radiotherapy and the implant failure, but such a result was not obtained for other factors.

### Conclusion

In spite of high favorable outcome with endosseous titanium implants, some cases of inevitable failure have been occurred, as well. Among the most significant causes of implant failure in early stages we could name lack of initial stability, surgical trauma, surgical-related infection, and occlusal overloading. This paper also concentrates on the major factors such as systematic diseases, microbiology, periodontitis, smoking, drug treatments (especially bisphosphonates), genetic, and a combination of the factors. Although results indicated that there are minor cases with definitive implant prohibition, smoking, especially in a higher level of consumption, is a significant factor in the implant failure. Further researches should reveal the combination of factors making the patients more vulnerable to peripheral mucositis and implant inflammation in that they contributed to the implant failure.

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